**Analysis Tool for Lunar Crescent Visibility Criteria Using Integrated Lunar Crescent Sighting Database**

**Hilalpy**

HilalPy is a python library that function as an analysis tool for lunar crescent visibility criteria using integrated lunar crescent sighting database. HilalPy is the product of the thesis, as discussed in Chapter 4. HilalPy is deposited at Python Package Index, PyPi.

**Installation of Hilalpy and its dependencies**

HilalPy is located at the PyPi repository. This mean that Hilalpy is publicly available on the internet and can be download from any server. Installation of Hilalpy is as follows

1. Navigate to HilalPy repository at PyPi to confirm HilalPy version. HilalPy is updated from time to time, thus it is importance to ensure that installation of HilalPy uses the latest version of HilalPy.

**Figure 5.14. HilalPy Repository at PyPi**

Graphical user interface, text, application, email

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2. Installation of HilalPy can be done by typing command “pip install HilalPy” on PowerShell Windows.

**Figure 5.15. Command for HilalPy Installation**

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**Figure 5.16. Successful Installation of HilalPy**

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4. Confirming the version of HilalPy. To confirm the version of HilalPy, a command “pip show HilalPy” can be entered on the PowerShell.

**Figure 5.17. HilalPy version confirmation command**

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**Figure 5.18. Hilalpy version confirmation result**

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5. Should the version of the Hilalpy is differ from the version of HilalPy from the PyPi website, the command “pip install Hilalpy --upgrade" can used to upgrade the python module.

6. Hilalpy has various dependencies in order to operate its lunar crescent observation analysis for lunar crescent visibility assessment. To install all HilalPy dependencies, a command below can be executed on the windows PowerShell.



**Figure 5.19. Command Execution for Dependencies Installation**

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Should all of the steps done properly, Hilalpy would be ready to use.

**Demonstration of Hilalpy**

HilalPy has three main function, visibility threshold analysis, contradiction rate analysis of condition style lunar crescent visibility criterion, and contradiction rate analysis of equation style lunar crescent visibility criterion.

**Lunar Crescent Visibility Variable Statistical Analysis**

Visibility threshold analysis requires four inputs from user, which are

1. figure

The output figure of the boxplot from the variable statistical analysis. Users requires to input the intended location for the output file. For example, if the user wants the output to be located at the download folder, the input would be;



Should the user want the output to be located at the desktop folder, the input would be;



2. csv\_stats

csv\_stats is the descriptive statistics result of the variable analysis. It contains the information of the mean, median, 1st quartile, 3rd quartile, maximum and minimum of the variable parameter. User requires to input the intended location for the output file. For example, if the user wants the output to be located at the download folder, the input is;



Should the user want the output to be located at the desktop folder, the input would be;



3. csv\_maxmin

csv\_maxmin is the variable parameter that sits at the minimum and maximum value. It represents as a threshold for lunar crescent visibility, and vital in the formation of a lunar crescent visibility criterion. User requires to input the intended location for the output file. For example, if the user wants the output to be located at the download folder, the input would be;



Should the user want the output to be located at the desktop folder, the input would be,



4. x

x is the variable that the user intended to apply the statistical analysis. There is specific syntax for x, which user need to refer to. The syntax is as shown in Table 5.3.

**Table 5.3. Syntax of Lunar Crescent Visibility for Hilalpy**

|  |  |
| --- | --- |
| Variable | Syntax |
| Lag Time | LT |
| Moon Age | MA |
| Arc of Vision | ArcV |
| Arc of Light | ArcL |
| Different in Azimuth | DAZ |
| Width | W |

User require to input the intended variable for statistical analysis. For example, if the user wants to conduct a statistical analysis for Lag time, the input would be;



Should the user want to conduct a statistical analysis for Arc of vision, the input would be;



5. To call the visibility threshold analysis, the code is



Should, all of the input is completed, the result are a boxplot and a descriptive statistical table, as shown in Figure 5.20.

**Figure 5.20. Hilalpy Variable Statistical Analysis Output**

Chart, box and whisker chart

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6. Use cases of HilalPy visibility threshold analysis.

A. User want to conduct a visibility threshold analysis on different in azimuth, and to store the output on the download folder.



The result would be as shown in Figure 5.21.

**Figure 5.21. Output File of Hilalpy Thres Function**

Chart, box and whisker chart

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B. User want to conduct a visibility threshold analysis on width, and to store the output on the document folder.



The result would be as shown in Figure 5.22.

**Figure 5.22. Output File of Hilalpy Thres Function**

Chart, box and whisker chart

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Graphical user interface, application

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**Conditional Style Lunar Crescent Visibility Criterion Contradiction Rate Analysis**

Hilalpy has the function to perform a contradiction rate analysis on conditional style lunar crescent visibility criterion called Cond. Cond require 8 inputs from the user which are,

1. figure

The output figure of the line graph overlay with scattered plot. User require to input the intended location for the output file. For example, if the user wants the output to be located at the download folder, the input would be



2. errorratetotal

errorratetotal is the result of the contradiction rate analysis of lunar crescent visibility criterion. It contains the information the position and negative contradiction rate of lunar crescent visibility criterion, based on whole data, naked eye data, and optical aided data of lunar crescent observation. User requires to input the intended location for the output file. For example, if the user wants the output to be located at the download folder, the input would be



Should the user want the output to be located at the desktop folder, the input would be,



3. x

x is the conditional variable of the lunar crescent visibility criterion. x located at the x-axis of the graph simulation. x user input must follow syntax from Table 5.3.

4. y

y is the conditional variable of the lunar crescent visibility criterion. y located at the y-axis of the graph simulation. y user input must follow syntax from Table 5.3.

5. conditionx

conditionx is the conditional variable parameter of the lunar crescent visibility criterion. conditionx located at the x-axis of the graph simulation.

6. conditiony

conditiony is the conditional variable parameter of the lunar crescent visibility criterion. conditiony located at the y-axis of the graph simulation.

7. limitx

limitx is the conditional variable parameter of the lunar crescent visibility criterion. limitx located at the x-axis of the graph simulation.

8. limity

limity is the conditional variable parameter of the lunar crescent visibility criterion. conditiony located at the y-axis of the graph simulation.

9. To use the HilalPy cond functions, the code is



Should, all of the input is completed, a line graph overlay on scattered plot and a contradiction rate table output is as shown in Figure 5.24.

**Figure 5.23. Output of HilalPy Cond function**

Chart, scatter chart

Description automatically generated

10. Use cases of HilalPy Cond.

A. User want to conduct a contradiction rate on a lunar crescent visibility criterion, which has condition of; arc of vision larger than or equal to 3.0 degree, and arc of light larger than and equal to 6.3 degree. The code execution would be;



The result is as shown in Figure 5.24.

**Figure 5.24. Output File of Hilalpy Cond Function**

Chart, scatter chart

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Graphical user interface, text, application

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A. User want to conduct a contradiction rate on a lunar crescent visibility criterion, which has condition of; different in azimuth larger than or equal to 4.0 degree, and width larger than and equal to 10 minute. The code execution would be;



The result is shown in Figure 5.25.

**Figure 5.25. Output File of Hilalpy Cond Function**

Chart, scatter chart

Description automatically generated

Graphical user interface, text, application

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**Equation Style Lunar Crescent Visibility Criterion Contradiction Rate Analysis**

HilalPy has the function to perform a contradiction rate analysis on equation style lunar crescent visibility criterion called *equa*. *equa* require 8 inputs from the user which are,

1. figure

The output figure of the line graph overlay with scattered plot. User requires to input the intended location for the output file.

2. errorratetotal

errorratetotal is the result of the contradiction rate analysis of lunar crescent visibility criterion. It contains the information the position and negative contradiction rate of lunar crescent visibility criterion, based on whole data, naked eye data, and optical aided data of lunar crescent sighting.

3. a

a is the equation variable of the lunar crescent visibility criterion. a located at the x-axis of the graph simulation. a user input must follow syntax from Table 5.3.

4. b

b is the equation variable of the lunar crescent visibility criterion. b located at the y-axis of the graph simulation. b user input must follow syntax from Table 5.3.

5. equation

equation is the equation of a lunar crescent visibility criterion. Equation is express in a in term of b. The equation must follow the python syntax for numeral expression and does not consider trigonometry function as an input. For example, Fotheringham lunar crescent visibility criterion is expressed as,

In the HilalPy *equa* function, Arc of Vision is expressed as a and equation, while difference in azimuth is expressed as x.

Another example is Alrefay lunar crescent visibility criterion, which expressed as,

In the HilalPy *equa* function, Arc of Vision is expressed as ‘a’ and ‘equation’, while width is expressed as ‘x’.

6. limita

limita is the conditional variable parameter of the lunar crescent visibility criterion. limita located at the x-axis of the graph simulation.

7. limitb

limitb is the conditional variable parameter of the lunar crescent visibility criterion. limitb located at the y-axis of the graph simulation.

8. To use the HilalPy *equa* function, the code is;



Should, all of the input is completed, a line graph overlay on scattered plot and a contradiction rate table shown as in Figure 5.26.

**Figure 5.26. Output of HilalPy *Equa* function**

Chart, scatter chart

Description automatically generated

10. Use cases of HilalPy *equa*.

A. User want to conduct a contradiction rate on a lunar crescent visibility criterion, which has equation of ;

. The code execution would be;



The result is as shown in Figure 5.27.

**Figure 5.27. Output File of Hilalpy *equa* Function**

Chart, scatter chart

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Graphical user interface, text, application

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B. User want to conduct a contradiction rate on a lunar crescent visibility criterion, which has equation of ;

. The code execution would be;



The result is shown in Figure 5.28.

**Figure 5.28. Result of the HilalPy *equa* Function**

Chart, scatter chart

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**Multirange Lunar Crescent Visibility Criteria**

Multirange lunar crescent visibility criteria are criteria that based on ranges of visibility, commonly include, easily visibility by naked eye, visibility by optical aided and not visibility. The multirange lunar crescent visibility criterion is adopted by Yallop (1998), Odeh (2004) and Qureshi (2010) in their lunar crescent visibility criterion. HilalPy *equa* function able to examine the contradiction rate analysis on the multirange lunar crescent visibility criterion, however it requires a mathematical manipulation on the expression of the lunar crescent visibility criterion, Taking the example on Yallop Lunar crescent visibility criterion, Yallop equation can be manipulated to expressed ArcV in term of q and w.

As the value of q is already supplied and ArcV and W is based on lunar crescent sighting data, and contradiction rate analysis using HilalPy *equa* function can be conducted. For criterion A, HilalPy code execution and result would be



**Figure 5.29. Odeh Criterion A**

Chart, scatter chart

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For criterion B, HilalPy code execution and result would be



**Figure 5.30. Odeh Criterion B**

Chart, scatter chart

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For criterion C, HilalPy code execution and result would be



**Figure 5.31. Odeh Criterion C**

Chart, scatter chart

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For criterion D, HilalPy code execution and result would be



**Figure 5.32. Odeh Criterion D**

Chart, scatter chart

Description automatically generated

For criterion E, HilalPy code execution and result would be



**Figure 5.33. Odeh Criterion E**

Chart, scatter chart

Description automatically generated

The user requires to combine the positive and negative contradiction rate to from the analysis of multirange lunar crescent visibility criterion.